

LOCATING UNIT, VEHICLE BODY ASSEMBLY MACHINE USING THE SAME AND METHOD THEREFOR

BACKGROUND OF THE INVENTION

5 The present invention relates to vehicle body assembly machines for use in vehicle body assembly lines of automobiles and, more particularly, a general-purpose vehicle body assembly machine and a method thereof specifically suited for positioning and supporting a plurality of panels which form a vehicle body.

10 In the related art, it has heretofore been a usual practice to utilize a general-purposes vehicle body assembly machine including locating units for positioning a work a preset position in accordance with a vehicle body assembling operation as disclosed in, for example, Japanese Patent No. 2745841.

5 With such a structure, a transfer truck is mounted with a plurality of locators each of which has an operating freedom in orthogonal three axes in X-, Y- and Z-directions. As shown in FIG. 1, each of the locators includes locating unit 101, which has a locating pin 102 and a clamp arm 103, with the plural locating units being used for positioning and clamping a given panel at the preset position for a subsequent transfer to a next work stage.

20 As shown in FIG. 1, further, the locating pin 102 of each locating unit 101 is associated with a seating detection means 105, such as a proximity switch, which is mounted in an outside area adjacent to the locating pin 102 via a bracket 106 for detecting whether the locating pin 102 is precisely inserted through a locating bore 104 of the panel W11 and whether the panel W11 is seated on the locating pin 102. Thus, the seating detection means 105 functions to detect the presence of seating or unseating state of the panel W11.

25 Also, the panel W11 is formed with an embossed portion 108, which is seated on a work seating surface 107 of the locating pin 102, in a concentric relationship with the locating bore 104. With such a configuration, if the embossed portion 108 is correctly seated on the work seating surface 107, the panel is clamped with the clamp arm 103 internally located in the locating pin 102.

SUMMARY OF THE INVENTION

With such a structure in the related art described above, the locator body has an operating freedom in the orthogonal three axes which enable a three-dimensional position of the locating pin 102 to be altered to permit the positioning operation of the panel of another car model. However, since mounting position of the seating detecting means 105 to be mounted adjacent the locating pin 102 is settled at a location depending on the shape of the panel, it is needed for the vehicle body assembly machine to be converted whenever panels of another car model are intended to be assembled, with an adverse affect on a general-purpose property of the assembly machine.

More particularly, in a case where the panel, to be positioned and supported with the locating pin 102, is altered to a panel W12 with a shape shown by a phantom line in FIG. 1, the presence of the seating detection means 105 and the bracket 106 remaining at a remarkably protruded area at the outside of the locating pin 102 causes the seating detection means 105, still remaining at its original location, to interfere with the panel W12. This results in need for the mount position of the seating detection means 105 to be converted whenever the panel W12 with an altered shape is manipulated, with a resultant excessive man-hour necessary for converting an equipment.

Further, when implementing a welding on the panel at an area closer to the aforementioned seating detection means 105 using a spot welding gun gripped by a welding robot, or when setting a traveling locus of the spot welding gun along a path in a close proximity to the seating detection means 105, similarly, there is a fear in that the spot welding gun and the seating detection means 105 mutually interfere with one another. For this reason, it is required for the mounting structure of the seating detection means 105 to be converted whenever the panel of the different shape is manipulated. Alternatively, it is undesirably required for the traveling locus of the spot welding gun, i.e. a teaching data to be modified, causing an impractical result.

On the other hand, a recent trend is to obtain a vehicle body assembly machine having a further simplified structure with a reduced spacing in view of a general-purpose property.

The present invention has been made with the above view in mind and

has an object of the present invention to provide a locating unit and a vehicle body assembly machine equipped with the locating unit, with the locating pin and a seating detection mechanism associated therewith having a capability of complying with a large number of kinds of works to allow the whole structure of the locating unit to truly have a general-purpose property.

It is another object of the present invention to provide a method for positioning and supporting a work in a fixed place with a locating unit equipped with a locating pin to be inserted through a locating bore formed in the work to allow a vehicle body assembly machine to have a general-purpose property.

According to a first aspect of the present invention, there is provided a locating unit equipped with a locating pin to be inserted through a locating bore formed in a work for positioning and supporting the work in a fixed place, said locating unit comprising: a locating pin having a root portion formed with a work seating surface; and a work seating detection mechanism mounted at said root portion and detecting the presence of seating of said work on said work seating surface.

With such a structure, the presence of the work seating detection mechanism mounted at the work seating surface of the root portion of the locating pin allows an occupying space to be minimized to provide a capability wherein when the locating pins and the locating bores of the works are normalized to be common to one another irrespective of the different kinds of the works, the work seating detection mechanism can be commonly used for a plurality of works of a large number of different kinds without converting the shapes or mounting structures of the work seating detection mechanism per se and the locating pin.

The work seating detection mechanism may be of any types such as a contact type, a non-contact type, a photoelectric type or an air pressure type, provided that a detector portion is exposed to the work seating surface of the root portion of the locating pin to detect the seating or unseating state of the work relative to the work seating surface in a turned-on or turned-off state.

According to a second aspect of the present invention, there is provided a vehicle body assembly machine for implementing a relative positioning operation among a plurality of panel-shaped works, which form a part of a

vehicle body of an automobile, prior to welding and joining the plurality of the works, said vehicle body assembly machine comprising: a plurality of locators independently mounted for respective works and each including a locating unit mainly constructed of a locating pin for positioning and supporting each of said works, said locating unit having a capability of self-isolating movement to provide a function of arbitrarily altering at least a two-dimensional position of said locating unit; wherein said locators individually perform said self-isolating movements between work set positions, wherein said works are set with respect to said respective locators, and a relative-positioning final location, wherein a mutual relative-positioning operation of said works are finally implemented, to individually move said locating units in forward or retracted directions to perform said mutual relative-positioning operation among said works; and each of said locating units includes a locating pin adapted to be inserted through a locating bore formed in each of said work for positioning and supporting said each work, said locating pin having a root portion formed with a work seating surface, and a work seating detection mechanism mounted at said work seating surface for detecting the presence of seating of said each work on said work seating surface.

According to a third aspect of the present invention, there is provided a locating unit equipped with a locating pin to be inserted through a locating bore formed in a work for positioning and supporting the work in a fixed place, said locating unit comprising: locating means having a root portion formed with a work seating surface; and detection means mounted at said work seating surface for detecting the presence of seating of said work on said work seating surface.

According to a fourth aspect of the present invention, there is provided a vehicle body assembly machine for implementing a relative positioning operation among a plurality of panel-shaped works, which form a part of a vehicle body of an automobile, prior to welding and joining the plurality of the work, said vehicle body assembly machine comprising: means for positioning and supporting each of said works and including a plurality of locating units each having a capability of self-isolating movement to provide a function of arbitrarily altering at least a two-dimensional position of said

locating unit; wherein said positioning and supporting means perform said self-isolating movements between work set positions, wherein said works are set with respect to said respective locating units, and a relative-positioning final location, wherein a mutual relative- positioning of said works are finally implemented, to individually move said locating unit in forward or retracted directions to perform said mutual relative-positioning operation among said works; and each of said locating units includes a locating pin adapted to be inserted through a locating bore formed in each of said work for positioning and supporting said each work, said locating pin having a root portion formed with a work seating surface, and a work seating detection mechanism mounted at said work seating surface for detecting the presence of seating of said each work on said work seating surface.

According to a fifth aspect of the present invention, there is provided a method for positioning and supporting a work in a fixed place with a locating unit equipped with a locating pin to be inserted through a locating bore formed in the work, said method comprising: preparing a locating pin having a root portion formed with a work seating surface, a work seating detecting mechanism mounted at said work seating surface and a clamp arm operable within said locating pin; positioning and supporting said work on said work seating surface; detecting the presence of seating of said work on said work seating surface with said work seating detection mechanism at said root portion; and clamping said work on said work seating surface with said clamp arm.

According to a sixth aspect of the present invention, there is provided a method for implementing a relative positioning operation among a plurality of panel-shaped works, which form a part of a vehicle body of an automobile, prior to welding and joining the plurality of the works, said method comprising: preparing a plurality of locators independently mounted for respective works and each including a locating unit having a capability of self-isolating movement to provide a function of arbitrarily altering at least a two-dimensional position of said locating unit, said locating unit including a locating pin adapted to be inserted through a locating bore formed in each of said work for positioning and supporting said each work, said locating pin having a root portion formed with a work seating surface, and a work seating

detection mechanism mounted at said work seating surface; operating said locators individually to perform said self-isolating movements between work set positions, wherein said works are set with respect to said respective locators, and a relative-positioning final location, wherein a mutual relative-positioning operation of said works are finally implemented to individually move said locating units in forward or retracted directions while performing said mutual relative-positioning operation among said works; detecting the presence of seating of said works on said work seating surface with said work seating detection mechanism; and clamping said works in said relative-positioning final location.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings, in which:

FIG. 1 is a schematic structural view illustrating a locating unit of the related art;

FIG. 2 is a plan view illustrating a schematic structure of a vehicle body assembly machine of a preferred embodiment according to the present invention;

FIG. 3 is a plan view of a locator jig which forms a mother body of the vehicle body assembly machine shown in FIG. 2;

FIG. 4 is a front view of the locator jig shown in FIG. 3;

FIG. 5 is a right side view of the locator jig shown in FIG. 3;

FIG. 6 is a view illustrating a detailed structure of a locator, for positioning a side panel, shown in FIG. 3;

FIG. 7 is a front view of the structure shown in FIG. 6;

FIG. 8 is a left side view of the structure shown in FIG. 7;

FIG. 9 is an enlarged view of a locating unit to be used in respective locators shown in FIGS. 3 to 5;

FIG. 10 is an enlarged partial cross sectional view of the locating unit shown in FIG. 9;

FIG. 11 is a left side view of the locating unit shown in FIG. 10;

FIG. 12 is an enlarged view of a clamp arm shown in FIG. 10; and

FIGS. 13A to 13C are schematic views illustrating a sequence of assembling panels in the vehicle body assembly machine shown in FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 is schematic plan view of a vehicle body assembly machine, including a locating unit of a preferred embodiment according to the present invention, and shows an example for performing relative positioning among four components parts, involving a dash lower panel (hereinafter referred to simply as a lower panel or panel) W1 which serves as a work, a substantially C-shaped dash upper cross member (hereinafter referred to simply as a cross member or a panel) W2 which also serves as a work and a pair of right and left cowl top side panels (hereinafter referred to simply as side panels or panels, respectively) W3, W4 all of which form a mother body of a dash panel D of an automobile, to obtain a ready state available for welding and joining prior to welding and joining steps of these component parts with respect to one another by spot welding.

Under a condition wherein the dash panel D is assembled as a part into a vehicle body, further, the cross member W2 is located on the lower panel W1 which separates a passenger compartment and an engine compartment from one another, with the side panels W3, W4 being located at both sides of the lower panel W1 and the cross member W2.

The vehicle body assembly machine shown in FIG. 2 is generally comprised of jig base 1 serving as a center of a locator jig J, a first work table 2 in which the lower panels W1 are aligned and stacked, a second work table 3 in which the cross members W2 and the side panels W3, W4 are aligned and stacked, a handling robot of a floor mount type, and a plurality of welding robots 5 (provided only one piece of welding robots being shown in FIG. 2) of tray styles mounted at an upper area of the jig base 1.

With such an arrangement, the lower panel W1 stacked on the first work pedestal is gripped by the handling robot 4 and is placed and positioned at a relative-positioning final location P1 on the jig base 1. Upon a completed positioning step of the lower panel 1, an operator M transfers a set of the cross member W2 and the pair of right and left side panels W3, W4 on the second work table 3 to work set positions P2, P3 on the jig base 1 for carrying

out a primary positioning step. Then, when the operator presses a given start switch, a self-isolating movement of the locator jig J allows the lower panel 1 and the cross member W2 and the pair of right and left side panels W3, W4 to be subjected to a mutual relative-positioning operation at the relative-positioning final location P1 to permit the welding robot 5 to perform the spot welding process. Also, depending on car models, it is possible for the cross member W2 or the side panels W3, W4 to be positioned with respect to the jig base 1 with the handling robot 4 commonly used for the lower panel W1.

FIG. 3 shows a detailed structure of the locator jig J, FIG. 4 is a front view of the locator jig J shown in FIG. 3, and FIG. 5 shows right side view of the structure shown in FIG. 3. The locator jig J includes the jig base 1 which is mounted with left and right locator pairs 6A, 6B and 7A, 7B for positioning the lower panel, a pair of locators 8A, 8B for positioning the cross member, locator pairs 9A, 9B and 10A, 10B for positioning side panels W3, W4. Each of these locators 6A, 6B~10A, 10B is constructed of an X-axis unit, a Y-axis unit and a Z-axis unit of a ball screw type driven by a NC motor, with the Z-axis unit being located at an uppermost area, which form a locator mother unit playing a role as a manipulator with an operating freedom in orthogonal three axes. In the locator mother unit, a distal end of the Z-axis unit is mounted with a locating unit 27 mainly composed of a locating pin 26. Thus, the locator is comprised of the locator mother unit and the locating unit 27. The locators 6A, 6B~10A, 10B are independently operable from one another to enable a self-isolating movement whereby each has a function to arbitrary alter a three-dimensional position of a distal end of each locating unit 27. Further, in the locators 6A, 6B and 7A, 7B for positioning the lower panel, the locating pin 26 of each locating unit 27 is directed upward. On the contrary, in the locators 8A, 8B and 10A, 10B for positioning the cross member and the side panels, the locating pin 26 of each locating unit 27 is transversely directed.

Among the plural locators 6A, 6B~10A, 10B, a typical example of a detailed structure of the locator 9A for positioning the side panel is described below in detail with reference to FIGS. 6 to 8. In FIGS. 6 to 8, the X-axis unit 15 is constructed of an X-axis motor 11, an X-axis base 13 which contains a

ball screw 12 driven with the X-axis motor 11, and an X-axis slider 14 mounted on the X-axis base 13 for sliding movement with the ball screw 12. Likewise, the Y-axis unit 20 includes a Y-axis motor 16, a Y-axis base 18 slidably mounted on the X-axis slider 14 which contains a ball screw 17 driven with the Y-axis motor 16, and a Y-axis slider 19 mounted on the Y-axis base 18. Similarly, the Z-axis unit 25 includes a Z-axis motor 22, a Z-axis base 23 connected to the Y-axis slider 19 by means of a flange 21 and containing a ball screw driven with the Z-axis motor 22, and a Z-axis slider 24 mounted on the Z-axis base 23. In addition, an upper distal end of the Z-axis slider 24 is mounted with a transversely extending locating unit 27 mainly composed of the locating pin 26 having a clamping function as will be described below in detail. As will be apparent from the foregoing description, the locator 9A is enabled to alter the three-dimensional position of the locating pin 26 in associated relationship with the X-axis unit 15, the Y-axis unit 20 and the Z-axis unit 25. Also, the other locators basically have the same structures as that of the locator 9A with the locating unit 27 for positioning the side panel.

With the structure mentioned above, when performing the relative-positioning operation of the works using the plural locators, the plural locators are moved in the forward or retracted positions in a synchronized fashion with respect to one another, the vehicle body assembly machine has a more remarkably improved positioning stability in the relative-positioning mode.

As best seen in FIGS. 3 and 5, clamping units 28 are mounted on the jig base 1 at positions adjacent the locator pair 6A, 6B and the locator pair 7A, 7B, respectively, for positioning the lower panel. Each of the clamping units 28 includes a post 29 which stands upright from the jig base 1, and a swing type clammer 31 fixedly mounted to an upper distal end of the post 29 and having an air cylinder 30 for driving the clammer 31. The lower panel W1, which forms the mother body of the dash panel D, is positioned and supported with the locators 6A, 6B and 7A, 7B and is also simultaneously clamped with the pair of clammers 28, 28.

FIGS. 9 to 11 show a detailed structure of the locating unit 27 to be mounted to the distal end of each of the locators 6A, 6B~10A, 10B. The

locating unit 27 includes a hollow post section 33 having its lower end formed with a mounting flange 32, a clamp cylinder 34 composed of an air cylinder or a hydraulic cylinder formed in a substantially rectangular pole shape and connected to the hollow post section 33 in a concentric relationship, and a tapered locating pin 26 fixedly secured to an upper distal end of the hollow post section 33 via a spacer 36 by means of a plurality of fixture bolts 37 and having a root portion formed with a seating flange section 35 with a work seating surface 35a.

As best seen in FIG. 10, the locating pin 26 is axially formed with an elongated slit 38 which penetrates through the locating pin 26 in a radial direction and which communicates with an internal space of the post section 33 to allow a clamp arm 39, formed in a substantially key configuration shown in FIG. 12, to be inserted through the elongated slit 38 and the internal space of the hollow post section 33 as a clamping unit. An upper distal end of the clamp arm 39 protrudes outward from an opening portion 40 formed at the base portion of the locating pin 26, and the other lower end of the clamp arm 39 is coupled to a piston rod 41 of the clamp cylinder 34. In addition, a substantially L-shaped recessed cam 42 is held in engagement with a fixed pin 43 radially and transversely extending from the post section 33. With such an arrangement, when protruding and retracting the piston rod 41 of the clamp cylinder 34, the clamp arm 39 is caused to operate in a clamping and unclamping operation between the clamping position C1 and an unclamping position C2. Especially during the clamping operation, the distal end of the clamp arm 39 and the seating flange 35 are brought into a clamped condition shown in FIG. 10 to clamp a given panel such as the side panel W3 in a fixed place. With such an arrangement, the locating pin 26 collectively incorporates the original positioning and supporting function and the work seating detective function as well as the work clamping function in the mother body, resulting in a further miniaturized structure with a reduced spacing.

On the other hand, the panel W3, which is positioned with the locating pin 26, is formed with a locating bore R and an embossed portion E around an circumferential periphery of the locating bore R to allow the locating pin 26 and the locating bore R to be mutually mated with one another and to concurrently allow the embossed portion E to be seated on the seating flange

35 to effectuate the final positioning of the locating pin 26.

Inside the post section 33 of the locating unit 27, a shaft 44 with stepped diameter portions is located in parallel with a central axis of the locating pin 26 for sliding movement and is urged leftward as shown in FIG. 11 by means of a compression coil spring 45. A small diameter upper end of the shaft 44 is coupled to a coupling plate 46, which laterally extends inward to have an area, offset from the shaft 44, to which a lower distal end of a detection pin 47 is connected and extends in parallel to the shaft 44 to allow an upper end of the detection pin 47 to protrude or retract from the seating flange 35 of the locating pin. Further, in the absence of the panel W3 on the seating flange 35 with the detection pin 47 protruded upward from the seating flange 35, seating the given panel W3 on the seating flange 35 allows the detection pin 47 to retract in the seating flange 35 for thereby wholly retracting the shaft 44.

Further, a work-seating detection mechanism 49 includes a proximity switch 48 which is mounted to the flange 32 of the hollow post section 33 at a location opposed to a bottom end of a large diameter portion of the shaft 44. With such a structure shown in FIG. 10, when the detection pin 47 remains protruded from the seating flange 35 with the bottom end of the large diameter portion of the shaft 44 remaining separated from the proximity switch 48, the proximity switch 48 is turned off. In contrast, the presence of the panel W3 on the seating flange 35 allows the detection pin 47 and the shaft 44 to be displaced in sliding movement such that the proximity switch 48 is turned on. With the provision of the work seating detection mechanism adapted to mechanically detect the presence of the seated condition of the work responsive to the protruding or retracting movements of the detection pin followed by the seating or unseating steps of the work on the work seating surface, it is possible for the locating pin to detect the presence of or absence of the work on the work seating surface in a more precise manner, resulting in a highly improved reliability in detection of the work on the work seating surface.

Thus, the shaft 44, the detection pin 47 and the proximity switch 48 constitute the work-seating detection mechanism which serves as a work-seating detection means for detecting seating or unseating states of the panel W3 with respect to the seating flange 35. Therefore, the sliding

displacement of the detection pin 47 and the shaft 44 owing to the seating phase of the panel W3 with respect to the seating flange 35 enables the proximity switch 48 to be turned on or turned off for detection.

5 In accordance with the vehicle body assembly machine thus constructed, consequently, when supplying the lower panel W1, which is the mother body of the dash panel D as shown in FIG. 2, to the jig base 1 using the handling robot 4, the locating pin 26 of the locating unit 27 is positioned and retained in such a position as to allow the locators 6A, 6B to position the lower panel W1 to the final relative position completed area P1. On the other hand, the locators 8A, 8B for positioning the cross member and the locators 9A, 9B and 10A, 10B for positioning the side panels position and retain the respective locating pin 26 of the relevant locating units at the work set positions P2, P3, respectively.

That is, the locators 8A, 8B for positioning the cross member support and retain the locating pins 26, 26, of the relevant locating units 27, 27, at respective positions retreated from the relative-positioning final location P1 by a given amount in the Y-direction and lowered from the relative-positioning final location P1 by a given amount in the Z-direction. Also, the locators 9A, 9B and 10A, 10B for positioning the side panel support and retain the respective locating pins 26, 26, of the relevant locating units 27, 27 at respective positions retreated from the relative-positioning final location P1 by a given amount in the X-direction and lowered from the relative-positioning final location P1 by a given amount in the Z-direction.

25 Then, when the lower panel W1 is supplied to and set on the jig base 1 by the handling robot 4, the locating bores R, formed at given locations of the lower panel 1 as seen in FIG. 10, are brought into engagement with the relevant locating pins 26 of the respective locators 6A, 6B and 7A, 7B and, simultaneously, the embossed portions E are brought into the seated condition with respect to the relevant seating flanges 35 of the base portions of the respective locating pins 26. As such, a primary positioning operation is completed for the lower panel W1 in conjunction with the relevant locators 6A, 6B and 7A, 7B for the positioning of the lower panel. When this takes place, also, the clamp units 28, located adjacent the relevant locators 6A, 6B and 7A, 7B for the positioning of the lower panel remain in the unclamped

states.

Upon completion of the primary positioning step of the lower panel W1, which forms the mother body of the dash panel D, in a manner described above, the operator manipulates to set the cross member W2 and the pair of left and right side panels W3, W4, which form remaining components parts of the dash panel D, to the relevant locators 9A, 9B and 10A, 10B. In particular, the cross member 2 is set such that the locating bores R preliminarily formed in the cross member W2 are brought into engagement with the relevant locating pins 26 of the respective locators 8A, 8B remaining at the work set position P2 for the positioning of the cross member to allow the relevant embossed portions E around the locating bores R to be seated on the seating flanges 35 of the relevant locating pins 26 as seen in FIG. 10. Also, the pair of side panels W3, W4 are set such that the locating bores R preliminarily formed in the side panels W3, W4 are brought into engagement with the relevant locating pins 26 of the respective locators 8A, 8B remaining at the work set position P3 for the positioning of the side panels to allow the relevant embossed portions E around the locating bores R to be seated on the seating flanges 35 of the relevant locating pins 26 as seen in FIG. 10.

A typical view of a condition wherein the primary positioning operation has been completed in conjunction with the lower panel W1 and the cross member W2 and the pair of left and right side panels W3, W4, which constitute the component elements of the dash panel, in a manner as previously noted is shown in FIG. 2. As seen in FIG. 2, while the lower panel W1 remains in the relative-positioning final location P1, the other remaining cross member W2 and the side panels W3, W4 remain in the respective work set positions P2, P3. As a result, the respective panels W1 to W4 remain in the respective conditions before carrying out the relative positioning operation among the panels and remain in the respective positions separate from one another.

In a consecutive step, when the start switch (not shown) is turned on by the operator M after the setting of the aforementioned panels W1 to W4 has been completed, the clamp arm 39, which is contained in each of the respective locating pins 26 as seen in FIG. 10, is operated for clamping action, clamping the embossed portion E, formed around the locating bore R,

between the clamp arm 39 and the seating flange 35. At the same time, the pair of clamp units 28, located adjacent the relevant locators 6A, 6B and 7A, 7B for the positioning of the lower panel operates for the clamping action, thereby clamping the lower panel W1. In such a manner, the final positioning and clamping operations are completed for the panels W1 to W4 with the relevant locators 6A, 6B to 10A, 10B.

This occurs, the work seating detection mechanisms 49, mounted at the respective locating pins 26 as seen in FIG. 10, are actuated, detecting the presence of or absence of the relevant panels W1 to W4 associated with the locators 6A, 6B to 10A, 10B. If, in this instance, the presence of the seating of any panel relevant to the locating pin 26 is not detected by any possibility, a given alarm is produced to urge the operator M to confirm the presence of the panel with respect to the relevant locator.

Subsequently, upon confirmation of the presence of all the aforementioned panels W1 to W4, the locating pin 26 moves the cross member W2, which is positioned and retained with the locating pin 26 of the locating unit 27, forward into the relative-positioning final location P1 in the X-direction while raising the locating unit 27, remaining at the upper most end, by a given height in the Z-direction in a mutual synchronism with the pair of locators 8A, 8B for the positioning of the cross member. Thus, the cross member W2 is pressed onto the lower panel W1, which has been already retained at the relative-positioning final location P1 as seen in FIG. 13A, implementing the mutual positioning operation between the lower panel W1 and the cross member W2. When this takes place, the mutual positioning-completed condition between the lower panel W1 and the cross member W2 is self-retained with the relevant locators 6A, 6B, 7A, 7B and 8A, 8B which support the respective panels W1, W2 in their positioned states.

Further, since the locators 8A, 8B for the positioning of the cross member raises the cross member W1 in the Z-direction and then moves the same forward in the X-direction at once, it is possible for the work set position P2 for setting the cross member W2 at the locators for the cross member to be settled at a height lower than the relative-positioning final location P1, with a resultant reduction in load of the operator M with an improved workability. It goes without saying that the height of the work set position P2 may be settled

to an arbitrary position depending on a physical body of the operator M.

Upon completion of the mutual positioning step between the aforementioned lower panel W1 and the cross member W2, the left and right locator pairs 9A, 9B and 10A, 10B for the positioning of the side panels are actuated to raise the respective locating units 27 by the given amount in the Z-direction in the same manner as previously noted. At the same time, the side panels W3, W4, which are positioned and supported with the relevant locating units 27 and hence the locating pins 26, are moved with the associated locating pins 26 forward to the mutual positioning-completed position P1 in the Y-direction such that the side panels W3, W4 are pressed against the lower panel W1 and the cross member W2 which have been already located at the mutual positioning-completed position P1 as seen in FIG. 13B to allow the pair of left and right side panels to be mutually positioned in the Y- and Z-directions with respect to the lower panel W1 and the cross member W2 which have already remained in the mutual-positioning-completed condition.

Consecutively, when the mutual positioning operation of the side panels W3, W4 has been completed with respect to the Y- and Z-directions in the manner described above, the left and right locator pairs 9A, 9B and 10A, 10B move the side panels W3, W4, which are positioned and retained with the respective locating units 27 and, hence, the locating pins 26 forward to the relative-positioning final location P1 in the X-direction in synchronism with the left and right locator pairs 9A, 9B and 10A, 10B for the positioning of the side panels in the same manner as discussed above to allow the side panels W3, W4 to be pressed, in the X-direction, against the lower panel W1 and the cross member W2, which have already remained at the relative-positioning final location P1 as seen in FIG. 13C. Thus, the mutual positioning operation of the pair of left and right side panels is performed in the X-direction with respect to the lower panel W1 and the cross member W2 which remain in the relative-positioning final position.

With such positioning steps mentioned above, the relative-positioning operation is completed in the three-dimensional direction, i.e. X, Y and Z directions among the lower panel W1, the cross member W2 and the side panels W3, W4 which form the component elements of the dash panel,

rendering the respective panels W1 to W4 to be mutually held in intimate contact with one another at a proper joining position. Then, a welding command signal is applied to the welding robot 5, shown in FIG. 2, which remains at a stand-by condition, thereby implementing spot welding steps to join the joining parts of the adjoining panels, completing the assembly of the dash panel D, composed of the component elements, involving the aforementioned lower panel W1 and the cross member W2 and the pair of side panels W3, W4.

In the preferred embodiment of the present invention, it is, of course, possible for the three-dimensional positions of the locating units 27 (including the respective locating pins 26) remaining at the distal ends of the respective locators 6A, 6B to 10A, 10B to be arbitrarily altered. In addition, the presence of the original functions of the locating pins 26 of the respective locating units 27 as well as the clamping functions of the clamping means composed of the clamp arms 39 and the associated work seating detection mechanisms 49 contained in the respective locating pins 26 allow the detection pins 47 of the respective clamp arms 39 and the work seating detection mechanisms 49 to effectively operate in the respective regional areas of the seating flange portions 35 of the base portions of the relevant locating pins 26. Thus, there is no fear that excessive parts or portions thereof protrude outside the locating pins 26, respectively, resulting in a miniaturized and simplified structure in each of the locating units 27.

Accordingly, even in a case where an assembly work is performed for a dash panel of a car model different from the dash panel D which has been assembled or in a case where dash panels D of different car models are intended to be assembled in a so-called mixed flow production system, preliminarily normalizing the size of the locating bores R and the size of the embossed portions E among the relevant component elements of the respective dash panels of the different car models enables the locating pins 26 to be commonly used for the vehicle bodies of all car models without the need for any modification in the work-clamping functions and the work seating detecting functions, resulting in an extremely advantageous effect in a general-purpose usage in a vehicle body assembly line.

In accordance with the present invention, since the work seating detection

mechanism, which detects the work seated on the work seating surface, is mounted at the work seating surface of the root portion of the locating pin, there is no protruded part of the work seating detection mechanism in the vicinity of a circumferential periphery of the locating pin. Thus, it is possible for only a substantially regional area of the locating pin to display a capacity for the positioning function and the seating state detecting function with only the locating pin. Consequently, preliminarily normalizing the sizes of the locating pin and the locating bore correlated therewith, notwithstanding the works of the different kinds, enables not only the locating pin but also the work seating detecting function to be commonly used for the works of the plurality of kinds. This results in an extremely improved generous-purpose property of the vehicle body assembly machine without the need for converting any component parts or equipment owing to the change of the work that would be otherwise caused in the related art practice.

Another important advantage of the present invention concerns the vehicle body assembly machine mounted with the plurality of locators, each of which is mounted at its upper distal end with the locating unit which has a function of self-isolating movement to enable at least two-dimensional position of the locating unit to be arbitrarily altered. With such a function, the respective locating units are individually moveable in the forward or retracted positions with the aforementioned self-isolating movements using at least the respective operating freedoms in the two-dimensional plane for thereby implementing the relative-positioning operation among the respective works. As a result, there is no need for preparing an additional shifting unit to perform the relative-positioning operation specific for the particular work positioned with and supported by the selected locator separately from the locators, making it possible for providing simplified and miniaturized structure in equipment in a reduced spacing.

A further important advantage of the present invention concerns a capability of readily confirming the presence of or absence of the works relative to the locators using the work seating detective function whereby the vehicle body assembly machine has an improved operating reliability as well as the work detective function. Also, since the work set positions of respective locators are enabled to be arbitrarily altered if desired, the works are set to the

locators by presetting the work set positions at respective optimum positions to cope with the operator's physical body, with a resultant favorable efficiency in the workability.

The entire content of Japanese Application No. P2001-22854 with a filing
5 date of January 31, 2001 is herein incorporated by reference.

Although the present invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above and modifications will occur to those skilled in the art, in light of the teachings. The scope of the invention is defined with
10 reference to the following claims.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211